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(54) A DEVICE FOR FOCUS MAINTAINING IN AN OPTICAL INSTRUMENT

(71) We, COMMISSARIAT A L'ENERGIE ATOMIQUE, an organisation created in France by ordinance No. 45—2563 of 18th October 1945, of 29 rue de la Federation, Paris 15e, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a device for maintaining the focussing adjustments of an optical instrument. The invention is particularly but not exclusively, suitable for use in microscopes. More particularly, the invention relates to a device which permits automatic control of focusing of an objective lens according to the image under observation in order to provide compensation for displacements of the object itself, for surface irregularities of the stage or of said object, for mechanical faults which arise during sweeping movements or, finally, for thermal expansion processes which take place during observations carried out over long periods.

According to the invention there is provided a device for maintaining focusing adjustment of the objective lens of an optical instrument, comprising electro-magnetic translation means for causing said objective lens to carry out translational movements in a direction along or substantially parallel to the optical axis of said lens, means for introducing a spherical aberration into the image beam from the objective lens so as to either increase or reduce the light intensity of said beam according to the direction of out-of-focus variation in focusing and a light-sensitive system which receives said beam and generates an electric signal for controlling said translation means to re-establish correct focusing.

In order that the invention may be more readily understood it will now be described with reference to the single figure of the accompanying drawings which illustrates one form of construction of said device according to the invention.

The figure illustrates the manner in which focusing of a microscope is maintained in accordance with the invention while observation is in process, the objective lens and the stage of said microscope being shown diagrammatically at 1 and 2 respectively. The objective lens 1 is screwed onto a plate 3 which forms the base of a casing 4. Said plate is pierced by an annular opening in which is mounted a deformable diaphragm 5 of mild steel. An annular electromagnet 6 disposed opposite to said diaphragm has the intended function of attracting said diaphragm to a greater or lesser extent according to the intensity of the excitation current, that is to say of producing a variation in the distance between the objective lens 1 and the stage 2. The winding of said electromagnet is supplied with direct current from a generator or battery 7; and two potentiometers 8 and 9 are mounted in series in the circuit with a safety fuse 10. The potentiometer 9 adjusts the sensitivity of movement of the diaphragm by varying the intensity of the current within the winding of the electromagnet 6; the potentiometer 8 controls the movement of said diaphragm by energizing the electromagnet 6 to a greater or lesser extent.

Inasmuch as the deformation of the diaphragm 5 does not comply with a linear law as a function of the excitation, the winding of the control potentiometer 8 is designed so as to introduce the requisite linearity.

The image supplied by the objective lens 1 is divided into two parts by means of a binocular which is disposed at 11; one part is

intended either for direct observation as shown in the figure or for photography or motion picture photography whereas the other part is intended to permit detection of variations in focusing and automatic compensation for such variations by displacement of the objective lens 1, this being achieved by modifying the current which energizes the electromagnet 6.

To this end, a spherical aberration variator is interposed at 12 in the image beam which is not intended for observation for the purpose of introducing a substantial spherical aberration in the image. Under these conditions, since focusing is carried out as a result of operation of the potentiometer 8 in respect of a mean position of the object shown diagrammatically on the stage at 13, this position being chosen by the observer, any degree of de-focusing causes a variation in contrast in the details of the image. This in turn results either in brightening or darkening of the area under observation according to the direction of defocusing. It is accordingly only necessary to detect these variations in luminous flux, to convert them to electric signals and to feed said signals into the supply circuit of the electromagnet in order to correct the focusing.

Any photo-sensitive detector of the photo-emissive or photo-resistant type which is inserted in the circuit and receives the image beam which exhibits spherical aberration may be employed. However, the assembly which is illustrated not only carries out this detection but also provides automatic compensation for parasitic variations in illumination of the field under observation, with the result that it is sensitive only to variations in contrast resulting from variations in focussing. Said assembly is essentially made up of a photo-emissive cell 14 and a photo-resistant cell 15 which each receives a distorted image of the object 13 from an ocular-binocular disposed at 16 via the lenses 17 and 18 respectively. The position of the lens 18 is adjusted so that the photo-resistant cell should receive the total luminous flux which passes completely through the entire field under observation in the focussing plane. On the other hand, the position of the lens 17 is so adjusted that the photo-emissive cell 14 integrates the flux corresponding to the same field but distinctly outside the focusing plane.

The two cells are mounted in series in the circuit which supplies current to the electromagnet 6 between the generator 7 and the safety fuse 10. Thus, by virtue of a judicious choice of characteristics of these two cells and after the current has been correctly regulated within the circuit by means of the control potentiometer 8, the variations in the excitation current of the electromagnet 6 are controlled only by the variations in contrast caused by the variations in focusing. In fact, if an increase either in illumination of the field or in opacity of the preparation were to occur during observation, for example, there takes place at the level of the photo-resistant cell 15 an increase Δr in the resistance of the circuit, with a decrease Δi in the corresponding current whilst the current which is fed into said circuit by the photo-emissive cell 14 undergoes an increase Δi which exactly compensates for the parasitic variation of the resistance of the circuit. On the contrary, if there takes place a reduction in illumination of the field or in opacity of the preparation which results in an increase in current within the photo-resistant cell 15, said increase is automatically compensated by a reduction of the current which is fed into the circuit by the photo-emissive cell 14.

In consequence, and since any parasitic variation of the current within the excitation circuit of the electromagnet 6 is automatically eliminated by virtue of the function performed by the photo-emissive cell 14, a variation in focusing towards reduction in the distance between the objective lens 1 and the object under observation 13 causes a reduction of the luminous flux received by the photo-resistant cell 15 by reason of defocusing or owing to the presence of spherical aberration; the excitation current of the electromagnet 6 accordingly undergoes an increase which has the effect of moving the objective lens away from the stage in order to restore the focus. Similarly, a variation in focusing towards an increase in the distance between the objective lens and the object causes an increase in the luminous flux received by the photo-resistant cell 15; the excitation current of the electromagnet 6 accordingly undergoes a reduction which has the effect of moving the objective lens nearer to the stage in order to restore the focus.

WHAT WE CLAIM IS:—

1. A device for maintaining focusing adjustment of the objective lens of an optical instrument, comprising electro-magnetic translation means for causing said objective lens to carry out translational movements in a direction along or substantially parallel to the optical axis of said lens, means for introducing a spherical aberration into the image beam from the objective lens so as to either increase or reduce the light intensity of said beam according to the direction of out-of-focus variation in focusing and a light-sensitive system which receives said beam and generates an electric signal for controlling said translation means to re-establish correct focusing.

2. A device in accordance with claim 1, wherein said system includes a photo-resistant detector.

3. A device in accordance with claim 1,

wherein said system includes a photo-emissive detector.

4. A device in accordance with claim 1, wherein said system comprises a photo-emissive detector and a photo-resistant detector connected in series, one of said detectors being intended to receive the luminous flux which passes through the entire field observed through the objective lens in the focusing plane, the other detector being intended to receive the flux which corresponds to the same field but which is located distinctly outside the focusing plane whereby automatic focusing correction is obtained.

5. A device in accordance with any of the preceding claims, wherein said objective lens is mounted at the centre of a thin metallic plate which is placed opposite to an electromagnet of said electromagnetic translation means and is deformable under the action of said electromagnet, so that a variation in the intensity of the excitation current of the electromagnet causes a displacement of the objective lens along the axis thereof.

6. A device in accordance with claim 1, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1260245 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*